

# Care of pediatric neurosurgical patients in Iraq in 2007: clinical and ethical experience of a field hospital

## Clinical article

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**Object.** Care for host-nation pediatric casualties and disease or nonbattle injuries is an essential mission of deployed military medical assets. Clinical experience with pediatric patients at field hospitals has been increasingly reported since 2001, with neurotrauma identified as a major cause of morbidity and death in this population. A concentrated pediatric neurosurgical experience at a deployed medical facility has not been reported. The authors reviewed their experience with pediatric neurosurgical patients at a field hospital in Iraq in 2007 to provide insight into the management of this patient population.

**Methods.** A retrospective review was conducted using a prospective database constructed by the authors for quality improvement during a single combat rotation in 2007.

**Results.** Forty-two patients among 287 consultations were 17 years of age or younger. Twenty-six of these children were 8 years old or younger. Penetrating head injuries were the most common indication for consultation (22 of 42 patients). Twenty-eight of 130 surgical procedures were performed in the children. One patient died in the perioperative period, for a trauma-related operative mortality rate of 4%. Seven patients received palliative care based on the extent of presenting injuries. Twenty-five patients were discharged with minimal or no neurological deficits.

**Conclusions.** Pediatric patients represent a significant proportion of the neurosurgical patient volume at field medical hospitals in the Iraqi theater. The mature medical theater environment present in 2007 allowed for remarkable diagnostic evaluation and treatment of these patients. Penetrating and closed craniospinal injuries were the most common indication for consultation. Disease and nonbattle injuries were also encountered, with care provided when deemed appropriate. The deployed environment presents unique medical and ethical challenges to neurosurgeons serving in forward medical facilities. (DOI: 10.3171/2010.6.PEDS1031)

**KEY WORDS** • deployment neurosurgery • pediatric trauma • penetrating head injury • penetrating spine injury • bioethics

UNCONVENTIONAL warfare has dramatically shifted the burden of casualties from the soldier to the civilian population. Over the past 20 years, civilians have sustained the majority of injuries on the modern battlefield.<sup>1</sup> Natural curiosity and lack of protective equipment have combined to produce the injury and death of countless children in war-torn countries around the world. In the

current conflicts in Iraq and Afghanistan, children have constituted a significant portion of the casualties, making up some 10% of all admissions at US combat support hospitals.<sup>20</sup> Among this patient population, head injuries were present in 10–15% and represent the leading cause of death in pediatric patients at US military facilities.<sup>9</sup> In this same population, children 8 years of age and younger have a higher risk of death due to CNS injury than older children or adults.<sup>18</sup> Pediatric neurosurgical patients thus constitute a select group of high-acuity patients capable of consuming significant medical resources in a deployed environment. This information has the potential to impact medical planning, logistics, and policy.

*Abbreviations used in this paper:* EMDG = Expeditionary Medical Group; GCS = Glasgow Coma Scale; GOS = Glasgow Outcome Scale; GSW = gunshot wound; JTTS = Joint Theater Trauma System; PHI = penetrating head injury; PSI = penetrating spine injury.

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## Methods

This retrospective study was conducted through a review of a prospectively maintained database compiled by the authors and containing data on all consultations and surgical procedures undertaken by the neurosurgical component of the US Army's 53rd Head and Neck Team attached to the Air Force's 332nd EMDG between April and September of 2007. Collected data included patient demographics, injury patterns, presenting neurological examination and radiographic findings, patient management, duration of stay, and neurological outcome as assessed by the GOS<sup>14</sup> at the time of discharge from our facility. Follow-up data on civilian casualties could not be obtained.

The 332nd EMDG was a 50-bed tent facility that served as the center for head and neck trauma within the Southwest Asia combat theater during the so-called surge of coalition forces in Iraq. The facility maintained an augmentable 16-bed intensive care unit and the capability to hold casualties for up to 2 weeks. Diagnostic capabilities included two 16-slice CT units, general diagnostic radiology equipment, and a full-service lab and blood bank. Surgical assets included neurosurgeons, otolaryngologists, ophthalmologists, and oral maxillofacial surgeons as well as general/trauma, vascular, orthopedic, and urological surgeons. The facility maintained 3 operating rooms capable of handling 2 cases simultaneously and standard neurosurgical equipment including spinal instrumentation (Fig. 1).

While the primary mission of the facility was the care of coalition casualties, noncombatant Iraqi nationals were treated according to established but flexible medical rules of engagement. Civilian patients at risk for loss of life, limb, or eyesight were provided treatment. In some cases, humanitarian treatment was also offered for non-life-threatening injuries. Command policy required civilian casualties to be transferred to local civilian facilities as soon as practical; few exceptions to the 14-day policy were allowed.

## Results

### Patient Demographics

Two hundred eighty-seven consultations were performed during the April to September time period (Fig. 2). Among these consultations were 77 Iraqi civilians (27%), and 42 (15%) of these were children 17 years or younger. Twenty-six of the children were 0–8 years of age. Among the 42 children were 29 boys.

### Epidemiological Characteristics

Penetrating head injuries affected the largest group of patients (22 of 42 children) (Fig. 3). Within this group, fragment wounds were the most common mechanism of injury (14 patients) followed by GSWs (7 patients) and stabbing/impalement injury (1 patient). Other injuries included 10 closed-head injuries, 5 PSIs, and 5 disease or nonbattle injuries. The latter group included a 1-month old child with a thoracolumbar myelomeningocele, a



Fig. 1. Field operating room in Balad, Iraq, circa 2007.

child with a scalp dermoid, 2 children returning for cranioplasty following prior decompressive craniectomy, and a child with an epidural abscess from a prior craniotomy for trauma at our facility.

### Patient Care

Of the 42 pediatric patients seen in consultation, 28 required surgical management, representing 22% of the 130 operative cases treated by the neurosurgical service. The surgical interventions performed included bifrontal craniotomy for the repair of an anterior skull base injury (3 cases), decompressive craniectomy (5 cases), local debridement and wound closure for PHI (10 cases), ICP monitoring only (4 cases), spinal instrumentation (1 case), spinal exploration/debridement with lumbar drainage for penetrating injury (1 case), autograft cranioplasty for replacement of a prior craniectomy (2 cases), wound exploration for infected cranioplasty (1 case), and excision of scalp dermoid (1 case). Ten consultations required only medical management, whereas 4 required palliative care in the emergency room given the severity of the presenting injuries.

### Patient Disposition

The average duration of stay for pediatric patients at our facility was 3.2 days (range 1–13 days). Patient disposition included 18 patients discharged home, 12 patients transferred to alternate regional field hospitals to facilitate transportation to home or to host-nation medical facilities, 8 deaths, and 4 discharges with unclear disposition. Neurological outcome at the time of discharge included death in 8 cases, minimal or no neurological impairment in 25 cases, a GOS score of 2 in 1 case, and a GOS score of 3 in 8 cases. More specifically, death occurred in 8 (22%) of 37 neurotrauma consults and 7 (32%) of 22 PHIs. Only 1 patient died following surgical intervention, for a trauma-related operative mortality rate of 4.2%. Four patients received palliative care due to unsalvageable injuries, and care was withdrawn from 3 patients in the operating room following intracranial pressure monitor placement during damage control thoracotomy/laparotomy for unstable

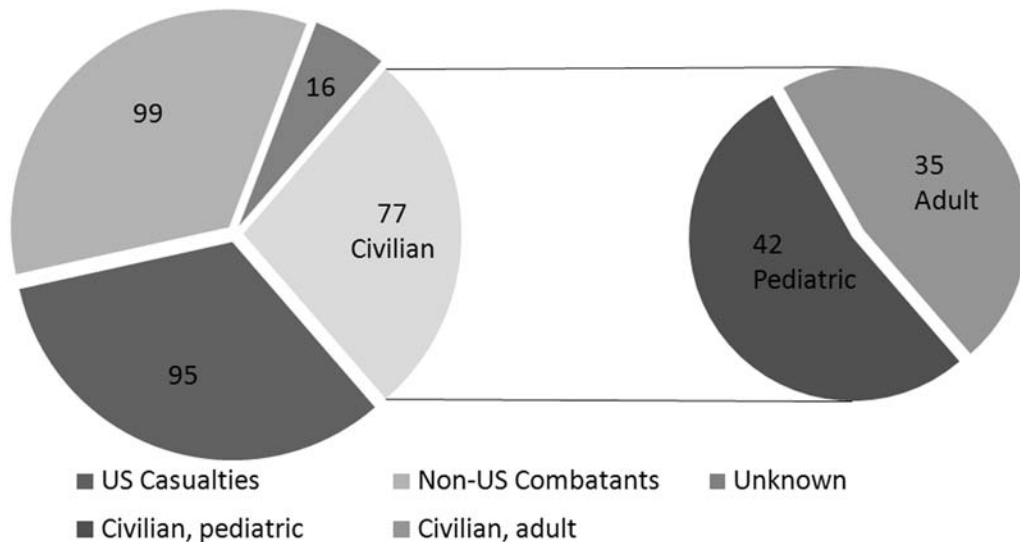


Fig. 2. Civilian neurosurgical consultations as a fraction of the total neurosurgical consultations during a combat rotation in 2007.

thoracoabdominal injuries. Of the remaining 15 patients with PHIs, 3 patients had GOS scores of 5, whereas 5 patients had GOS scores of 4 at the time of discharge.

### Discussion

This report is the first comprehensive review of pediatric neurosurgical disease encountered in a combat field hospital. It is generally underappreciated that non-combatant care constitutes a significant portion of workload at deployed US military medical facilities. An increase in publications framing and quantifying pediatric trauma treated at deployed medical facilities has and will continue to drive changes in personnel, equipment, and education in deploying medical assets.<sup>5,9,18,20</sup> Since 2003, changes have been implemented to include the assigning

of pediatric care providers to field hospitals, the creation of pediatric equipment sets by the US Army Medical Materiel Agency, and a concerted effort to create educational materials to prepare all deployed health care providers for pediatric patients in the theater.<sup>11</sup>

Neurosurgical care for closed and penetrating injuries of the head and spine has evolved considerably since the last sustained US military engagement in Vietnam.<sup>7</sup> Axial imaging, intracranial pressure monitoring, less aggressive debridement strategies,<sup>4</sup> hemicraniectomy,<sup>13,15</sup> and spinal instrumentation are examples of technology and techniques that predate the current conflict and have allowed for the provision of high-quality care to patients at field hospitals. The coordinated deployment of head and neck surgical providers has improved surgical care for patients with transfacial, transorbital, and skull base injuries.<sup>8</sup> A lack of standardized neurosurgical care at deployed medical facilities has led to fluctuations in treatment protocols at field hospitals during the current conflict. Our mature evaluation and treatment protocol evolved through one author's (R.J.T.) 18-month deployment experience prior to the collection of data for the current study.

Standard patient care included comprehensive initial trauma evaluation and resuscitation in accordance with the JTTS<sup>23</sup> and Advanced Trauma Life Support<sup>2</sup> protocols. Hemodynamically unstable patients were immediately taken to the operating room; intracranial pressure monitors were used diagnostically in those with concomitant head injuries to assist with clinical decision-making. All hemodynamically stable patients underwent a comprehensive evaluation beginning with reversed neurological examination consisting of, at minimum, a GCS score<sup>22</sup> or age-based equivalent<sup>10</sup> and pupil examination. Computed tomography studies of the head were obtained in all patients with an altered mental status or evidence of a PHI. Computed tomography angiography was performed in patients with transventricular/cisternal fragment trajectory, fragment trajectory crossing the anterior or lateral skull base, or discordant imaging and neurological ex-

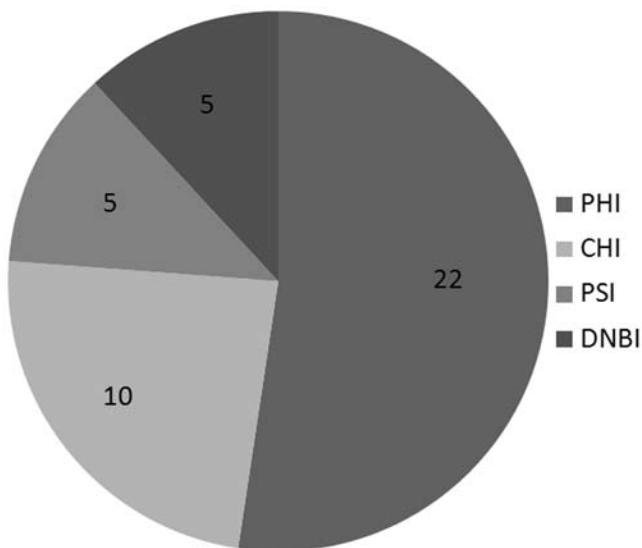


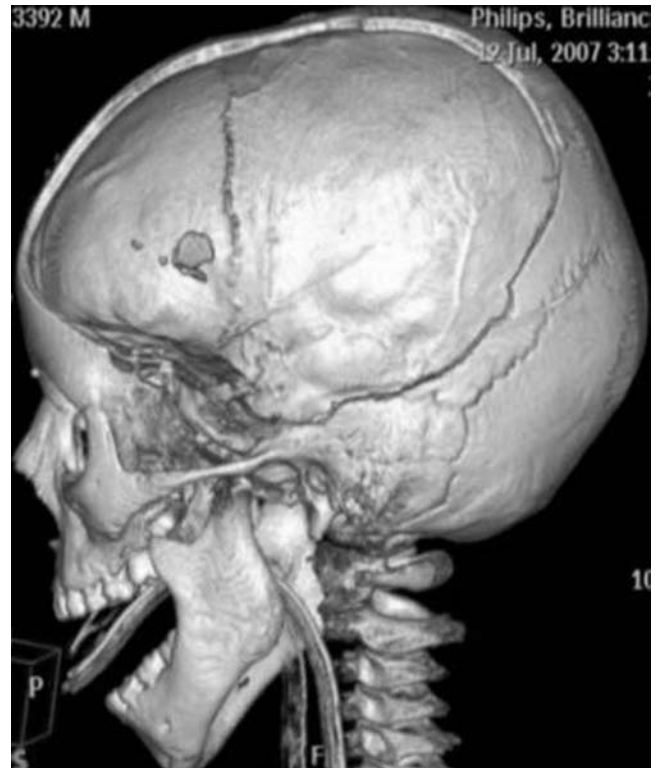
Fig. 3. Mechanism of injury/illness in 42 pediatric neurosurgical consultations in a combat rotation in 2007. CHI = closed head injury; DNBI = disease and nonbattle injury.

amination findings. Computed tomography scans of the cervical spine were obtained in patients with an impaired mental status or clinical findings suspicious for cervical spine injury; clinical clearance based on normal sagittal and coronal reconstructed images was our established standard of care. Further spinal imaging (CT or plain radiographs) were obtained when warranted.

Penetrating head injuries represented the most common indication for neurosurgical intervention and warrant further description. Management included aggressive removal of all scalp hair and thorough cleansing to allow for visualization of all sites of the penetrating injury. Treatment was designed 1) to minimize infectious risk related to wound contamination and CSF leakage and 2) to maximize functional neurological recovery. In patients with a good neurological grade (GCS Score 10 or greater), local debridement with scalp closure was performed as a definitive treatment. In patients with more significant injuries (GCS Score 9 or less with CT findings of elevated intracranial pressure, for example, cisternal effacement, midline shift, or nonevacuated mass lesion) craniectomy with expansion duraplasty was performed in the majority of cases. A Kempe "T" incision<sup>16</sup> (Fig. 4) was used to allow for wide hemicranial access, easy conversion to contralateral procedures, and maximal preservation of the vascular scalp pedicles. Hemicraniectomy was performed with extension to within 1 cm of the sagittal and lambdoid sutures with aggressive subtemporal decompression (Fig. 5) for maximal volume expansion (Fig. 6); bifrontal craniectomy extended behind the coronal suture and incorporated bilateral subtemporal decompression. Onlay dural substitute was routinely used; for expediency, "watertight" dural closure was not attempted for supratentorial injuries. Subcutaneous abdominal bone flap preservation was performed in all host-nation craniectomy patients to allow for late reconstruction. Combined management with ophthalmology/otolaryngology/maxillofacial surgical providers facilitated the care of patients with trauma to the orbits or skull base. Ventricular catheters were used judiciously based on infectious concerns in the field environment. Medical standards included the



**Fig. 4.** A T-incision used to balance wide hemicranial exposure and preserve scalp angiosomes.

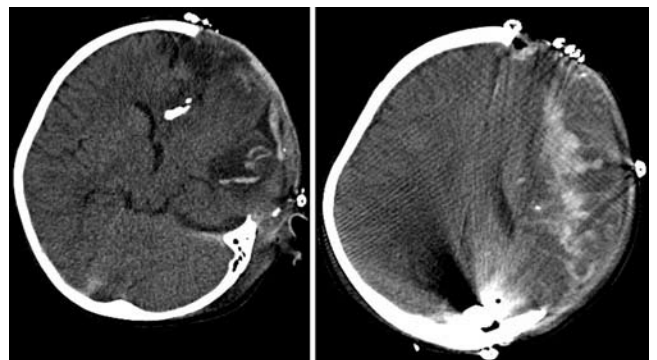


**Fig. 5.** A 3D CT reconstruction scan demonstrating the extent of bone removal required to achieve effective decompression for relief of malignant intracranial hypertension.

aggressive use of fractionated heparin for deep venous thrombosis prophylaxis following intracranial interventions (beginning 12 hours postsurgery) in postpubescent patients, hypertonic saline infusion as the osmotic agent of choice, and 24 hours of treatment with a third-generation cephalosporin for PHI surgically addressed within 6 hours of injury.

Despite the austere environment of our tent facility, resources did allow for advanced care of PSIs to include spinal instrumentation when required. Reconstructive procedures were performed to address both CSF fistula and instability in adult and pediatric patients.

Although long-term follow-up data were absent in



**Fig. 6.** Axial CT scan revealing the absence of strangulation of cortex within the middle cranial fossa (left) or at the posterior craniectomy margin (right) following the performance of an adequate decompressive craniectomy.

this study and outcome analysis was compromised by a short stay, several observations can be made regarding the available data. The mortality rate in this group of pediatric neurotrauma patients was significant: 32% of those with PHI. However, more than one-third (8 of 22 patients with PHI) had minimal or no neurological deficits at the time of discharge from our facility. Based on prior series in austere medical systems,<sup>21</sup> the majority of these patients likely went on to good long-term outcomes despite the poor state of host-nation health care availability in Iraq in 2007.

Appropriate patient selection is key to the delivery of optimal battlefield neurosurgical care. Field hospitals are not, by design, a substitute for host-nation acute care or rehabilitation hospitals. Their resources are limited, including personnel, equipment, blood products, and holding capacity, and there are security concerns when dealing with host-nation casualties. Host-nation medical capability and infrastructure are moving targets with a future that can't be predicted by current or past states. Familiarity with up-to-date local host-nation medical resources and standards of care are essential to the development of a treatment paradigm for incoming pediatric casualties. Such knowledge can be gathered through a number of military, civilian, and contractor sources on the ground.

In our experience, several patient- and system-specific issues outside the clinical examination impacted patient triage. Regional ethnic, religious, and political factors influenced delivery and acceptance of care by host-nation civilians. Families in some cases refused care for their children after learning that they would later be transferred to host-nation facilities in Baghdad. Fears of ethnic reprisals at home or on arrival to the new facility affected the family's willingness to consent to treatment. As another example, we learned that a controlled airway was not a management component in the patient with a head injury at Baghdad medical facilities due to a lack of critical care resources (M Faraj, personal communication, 2007).

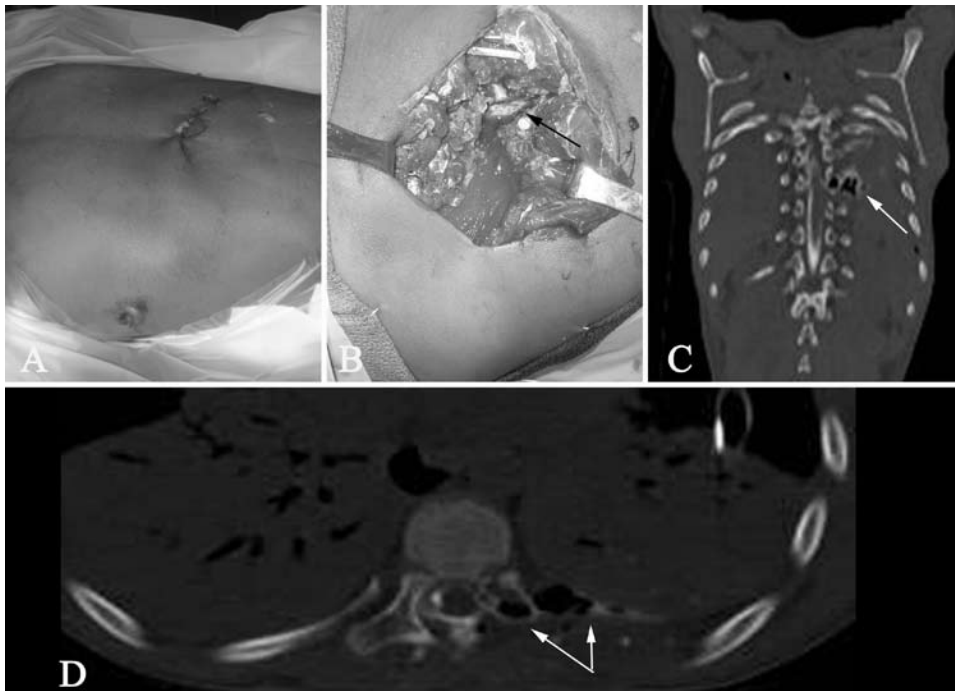
While ethical dilemmas are common in neurosurgery, battlefield ethics are particularly complex from both a legal and a moral perspective. As a deployed surgeon, familiarity with the legal and ethical responsibilities<sup>12</sup> in the provision of care to the wounded is essential. Regarding noncombatants, "the minimum standard of practice to achieve is that of the surrounding medical community, were it not involved in conflict. A higher standard is desirable if it can be achieved."<sup>19</sup> On the ground, the lines designating the status of casualties (civilian, military, or enemy combatant) were often nonexistent, resulting in doctrinal guidance from central military sources (US Army Medical Command, JTTS, and Central Command guidance) and local commanders that was discordant. Experience culled from earlier rotations as regards the fate of mortally wounded host-nation casualties, including children, led to careful consideration of the transport and treatment of some patients.

The inability to evacuate host-nation patients (including children) via Critical Care Air Transport Teams<sup>3</sup> to higher-level care facilities in Europe or the US led to a

necessary difference in the treatment of these patients. In 2007, an acknowledgment of the differences in standards of care for head-injured patients based on nationality was controversial. The JTTS initially acknowledged the futility of providing exhaustive care to select groups of injured patients in the clinical practice guideline for burn care:<sup>24</sup> "Experience among US treatment facilities in the past 3–4 years reveals no survivors among host nation casualties sustaining full thickness burns to 50% or greater total body surface area (TBSA). . . . Triage casualties with full thickness burns of 50% or greater TBSA as expectant and provide adequate comfort measures." Based on similar observations in head-injured children and adults during our rotation, host-nation casualties with devastating head injuries received palliative care in circumstances in which some coalition casualties did not. The most recent JTTS guidelines for the care of patients with severe head trauma<sup>25</sup> have aligned with this management paradigm.

Whenever possible, it was the goal of our surgical team to provide the highest level of care possible to all trauma patients at our facility, regardless of national origin. The treatment of patients with PSI represented an opportunity to deliver advanced medical care to patients who could be returned to host-nation medical assets. The Iraqi system had few resources to treat complicated spinal injuries and no facilities capable of spinal instrumentation at the time of our rotation; definitive treatment of host-nationals with spinal injuries was a role our facility accepted. We saw 2 children with penetrating injuries to the spine who required treatment at our facility, 1 for a thecal-pleural fistula (Fig. 7) and the other for instability following a bipedicular/facet trajectory thoracic GSW (Fig. 8). Both were successfully treated, stabilized, and returned to Iraqi care facilities.

Finally, the provision of humanitarian care for children with nontraumatic neurosurgical disease at field hospitals warrants a brief discussion. Such care is often provided at the discretion of the hospital commander with outstanding results.<sup>6</sup> The ability of a field hospital to accept these patients is dependent on a number of factors, including patient volume related to the primary hospital mission and resources available. While these cases can be incredibly rewarding, the provision of care must be viewed from the perspective of sustainability beyond the rotation of a single provider. The application of first-world treatment to third-world patients is, in our opinion, inappropriate if it deviates from local standards of care and requires subsequent follow-up that is not locally available.<sup>17</sup> Examples of the difficulties in such cases are tragic<sup>26</sup> and can create discord and resentment akin to those generated by other regional inconsistencies in foreign policy over the past several decades. After difficult deliberation, we decided against treating a 1-month-old child brought to our facility with a thoracolumbar myelomeningocele based on the refusal of the largest medical facility in Baghdad to treat the child at birth. Despite this decision, the family thanked us for seeing their child. "It's God's will," they told us through an interpreter. Their faith in this conviction is a cultural lesson we will never forget.



**FIG. 7.** Images obtained in an 8-year-old Iraqi child. A transthoracic GSW entering the left lateral chest wall and exiting the back in the midline (A). Operative exploration revealed extensive destruction of the posterior chest wall and unilateral damage to the posterior elements at T6–7 (B). The thecal sac appeared intact (black arrow) with no CSF leakage identified on initial exploration. Subsequent high-volume chest tube output led to the performance of CT myelography, whose images (C and D) revealed a thecal-pleural fistula (white arrows) that resolved with lumbar drainage.

### Conclusions

Wartime pediatric trauma is increasingly recognized as a significant challenge and the responsibility of deployed health care providers. For the deployed neurosurgeon, pediatric patients are a substantial population, for example, representing 15% of consultations and 20% of surgical interventions in the present case series. Excellent clinical results can be achieved in appropriately triaged patients. Medical and ethical preparation for deployment to a combat theater is essential to achieving success in this environment.

### Disclosure

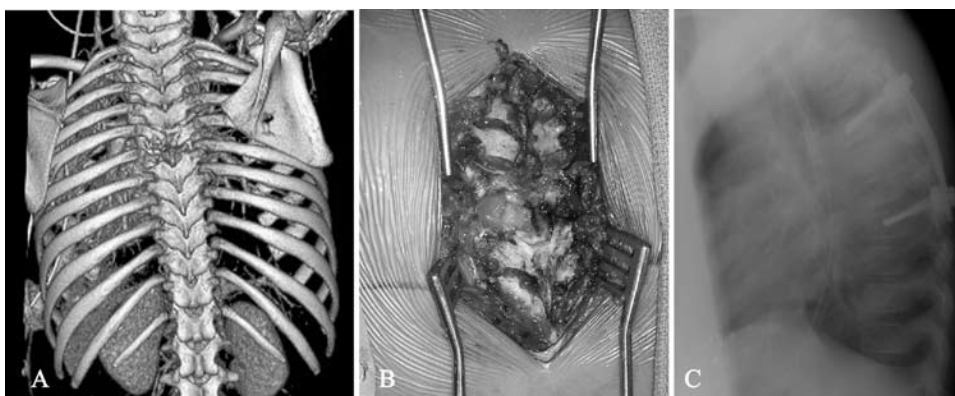
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the official policy of the Department of the Army, Department of Defense, or the US government.

Author contributions to the study and manuscript preparation include the following. Conception and design: Martin. Acquisition of data: Martin, Teff. Analysis and interpretation of data: Martin. Drafting the article: Martin. Critically revising the article: Martin, Spinella. Reviewed final version of the manuscript and approved it for submission: all authors. Administrative/technical/material support: Martin.

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**FIG. 8.** Images obtained in a 7-year-old Iraqi child. A: A transthoracic GSW entering the posterior chest wall through the right scapula. B: The bullet traversed and destroyed the left and right T5–6 facet joints and posterior spinal canal, rendering the child paraplegic. C: Posterior instrumentation was placed at the time of surgical exploration to prevent late kyphotic deformity.

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